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THE INTENSITY OF ELECTRONS AND PROTONS IN THE OUTER RADIATION BELT DURING THE PERIOD 1961 - 1964

by

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SUMMARY

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Results are presented of near-equatorial measurements in 1964 of the intensity of protons and electrons with respective energies $\geqslant 400$ kev and > 2 Mev in the center of the radiation belt. These results are compared with analogous data obtained in 1961.

* * *

Data were brought forth in the works [1, 2] about variations and absolute values of proton and electron intensity in the outer radiation belt on the basis of measurements conducted with the aid of devices on board the satellite Cosmos-41 [3]. These data are related mainly to the high latitude portion of the satellite trajectory. The results of analogous measurements in the near-equatorial zone ** are shown below for protons, registered by the silicon n-p detector in the 0.4 - 7 Mev energy interval and of electrons with energy greater than 2 Mev, registered by gas-discharge counters SI-ZBG.

The respective data for certain days of August and September 1964 are compiled in Table 1.

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* OB INTENSIVNOSTI PROTONOV I ELEKTRONOV VO VNESHNEM RADIATSIONNOM POYASE V PERIOD 1961 - 1964 gg.

** The satellite Cosmos-41 crossed the geomagnetic equatorial plane at the height ~ 26 thousand km in the region $L \approx 5$.

TABLE 1

Data	Ip, $cm^{-2}sec^{-1}ster^{-1}$	I_e, $cm^{-2}sec^{-1}$	K	Geomagnetic environment in the previous period
27 August	$3.5 \cdot 10^5$	$6.4 \cdot 10^2$	19	Quiet
28 August	$6 \cdot 10^6$	$1.3 \cdot 10^3$	12	Quiet
1 September	$3.1 \cdot 10^5$	$7 \cdot 10^3$	25	31 Aug.22h-2 Sept. 05h, G-storm, $\Sigma K=25$
11 September	$5.4 \cdot 10^5$	$1.1 \cdot 10^5$	15	6 Sept.23h-9 Sept. 04h, SC-storm, max $\Sigma K=31$

The second column of Table 1 shows the intensity of protons with $E_p \geqslant 400$ kev in the region of space characterized by the values of parameters $L = 5$, $B/B_0 = 1$ (B_0 being the value of the magnetic field in the geomagnetic equatorial plane). Inasmuch as during the time of measurements, the angle between the magnetic line of force on $L = 5$ and the axis of the directed proton detector constituted $\sim 30^o$, the experimental values were converted to the pitch-angle $\theta = 90^o$ in the assumption that the anisotropy coefficient of the angular distribution is $\alpha = 2$. Such a value of α was found from the experimental estimate of the altitude course on the basis of measurements with the help of the same detector[1]. In the third column the intensities of electrons with $E_e > 2$ Mev are figured, obtained with the aid of the counter SI-ZBG with a minimum shielding 0.84 g cm^{-2}. The comparison with the indications of the other counter SI-ZBG, shielded by a layer of matter > 3 g cm^{-2}, provides the basis to neglect the contribution of bremmstrahlung (in the center of the outer radiation belt). The sum of three-hourly values of K-indexes for twenty four hours is given in the column before the last, preceding the time of measurements, and in the last column, there is a brief characteristic of the magnetic environment previous to the measurements of [4].

It should be noted that a two-week quiet geomagnetic environment ($\Sigma K = 10 \div 15$) preceded the measurements of 27 and 28 August. From 2200 hours (Moscow time) on 31 August to 0500 hours on 2 September, the ground stations registered a magnetic storm with gradual commencement (G-storm). On 1 September $\Sigma K = 25$ was registered. From 2300 hours on 6 September to 0400 hours on 9 September a magnetic storm with sudden commencement (SC-storm) was noted that led to an increase of ΣK to 30 on 7 and 8 September[4]*.

* The sum of the planetary Kp-indexes for the indicated day did not differ from ΣK [5].

The analysis of data in Table 1 leads to the conclusion that the geomagnetic disturbances (on L = 5) are reflected substantially only in the intensity of hard electrons, whereas the intensity variations of protons are gathered within the limits of the factor of 2. This conclusion is in agreement with the results of the four monthly observations on the satellite Cosmos-41 in the high geomagnetic latitudes [1, 6]. Comparison may be made of absolute intensities of low-energy protons and hard electrons in 1961--1962 (measurements on the satellites Explorer-XII and Explorer-XIV) and in 1964 (measurements on the satellites Electron and Cosmos-41), that is, in a period of essentially different solar activity. Inasmuch as the measurements on various satellites were brought forth by nonidentical detectors, the comparison of results requires appropriate conversion. By the proton spectrum of the outer belt on L = 5, constructed by measurements on the satellite Explorer-XII of 26 August 1961 in the near-equatorial zone [7], it can be determined that the intensity of protons with $E_p \geqslant 400$ kev constituted $I_p \approx 5 \cdot 10^5$ cm^{-2}sec^{-1}ster^{-1}. Considering the conclusion of [8] that it is more correct to approximate the proton spectrum of the outer belt not by one, but by two exponents with different indexes and to make use of the tables of [8] we shall obtain $I_p(\geqslant 400$ kev$) \approx 3.5 \cdot 10^5$ cm^{-2}sec^{-1}ster^{-1}.

T A B L E 2

Data	Satellite	Detector, Threshold Energy	I_e, cm^{-2}sec^{-1}
5 Aug. 1961	Explorer-XII	A302; > 1.6 Mev	$(2 \pm 1) \cdot 10^6$ on $L \sim 4.5$
Sept. 1962-Feb. 1963	Explorer-XIV	A302; > 1.6 Mev	10^4-10^6 on $L \sim 4.8$
Feb. 1964	Electron-1, Electron-2	FEU; > 1.2 Mev	$2 \cdot 10^4$ on $L \sim 5$
Aug-Sept. 1964	Cosmos-41	SI-ZBG; > 2 Mev	10^3-10^5 on $L \sim 5$

The data of the satellite Explorer-XIV [9] may be extrapolated on L = 5 by the theoretical curve of [10] whereupon the intensity of protons $I_p(\geqslant 500$ kev$)$ is found to be $\sim 2 \cdot 10^5$ cm^{-2}sec^{-1}ster^{-1}, and that of protons $I_p(\geqslant 400$ kev$) \approx 3.3 \cdot 10^5$ cm^{-2}sec^{-1}ster^{-1}.

Therefore, neglecting the significant difference in solar activity in 1961--1962 and 1964, the mean absolute intensity of protons with $E_p \geqslant 400$ kev on L = 5 did not vary.

The data by absolute intensity of hard electrons in the outer radiation belt maximum, measured on the satellites Explorer-XII and Explorer-XIV[9, 11]Electron-1 and Electron-2[12]and Cosmos-41 are compared in Table 2.

Brought out in the last column are the values of electron intensity in the outer radiation belt maximum in the geomagnetic equatorial plane.

If we take into account that for the period of five monthly measurements on the satellite Explorer-XIV, the intensity of hard electrons of $\sim 10^4$ $cm^{-2}sec^{-1}$ was seldom observed, but at the time of observations on the satellite Cosmos-41, the indicated intensity exceeded the value 10^4 $cm^{-2}sec^{-1}$ only after substantial geomagnetic disturbances, we may, on the basis of the data in Table 2, draw a conclusion concerning the tendency toward decrease of the mean absolute intensity of hard electrons of the outer radiation belt in 1964 by comparison with 1961—1962.

Considering the noted higher difference in the variations of absolute intensity of hard electrons and low-energy protons in the framework of the formation theory of radiation belts at the expense of the drift and acceleration of charged particles from the boundary to magnetosphere depth[10],it can be assumed that the mean density of protons with energies in the tens of kev beyond the boundary of the steady capture varies little with the variation of solar activity. At the same time, the density of electrons with energy of the order of hundreds of kev, forming at drifting of hard electrons at the center of the outer radiation belt, arise sporadically only in the periods of relatively intense geomagnetic disturbances, providing the beginning of the formation of "diffusion waves."[13,14]Therefore, the intensity of hard electrons in the outer radiation belt is subject to long periodic variation connected with the solar activity cycle.

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* * * T H E   E N D * * *

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